Claims

1. Apparatus or arrangement with a heat source (1) consisting for example of at least one electric or electronic component or comprising one such component, with a heat sink (2) and with an intermediate layer (3) made of a thermally conductive material provided between the heat source and the heat sink, characterized in that
the intermediate layer (3) consists of an organic matrix with embedded nanofibers, and that the heat source (1) and the heat sink (2) bear with thermally conductive surfaces (1.1, 2.1) against the intermediate layer (3) with a surface pressure between approximately 0.1 and 100 bar.

2. Apparatus according to claim 1, characterized in that the organic matrix, at least at the operating temperature of the apparatus or of the heat source (1), is in a viscous or liquid state, for example a semi-liquid state.

3. Apparatus according to claim 1 or 2, characterized in that the organic matrix is already in the viscous or liquid state at room temperature, i.e. at a temperature between 10 and 30°C.

4. Apparatus according to claim 2, characterized in that the organic matrix is in the viscous or liquid state at a temperature higher than 30°C, for example at a temperature between 40 and 80°C.

5. Apparatus according to one of the foregoing claims, characterized in that the organic matrix contains at least one oil, for example a synthetic oil, such as silicone oil.

6. Apparatus according to one of the foregoing claims, characterized in that the organic matrix contains at least partially an elastomer, for example a completely or only partially cross-linked elastomer, e.g. synthetic elastomer

such as silicone rubber.

7. Apparatus according to one of the foregoing claims, characterized in that the organic matrix is at least partially a polymer, e.g. polycarbonate, polypropylene or polyethylene.

8. Apparatus according to one of the foregoing claims, characterized in that the percentage of nanofibers in the matrix is between 1 and 70 percent by weight in relation to the total mass of the intermediate layer (3), preferably between 5 and 20 percent by weight.

9. Apparatus according to one of the foregoing claims, characterized in that the nanofibers have a thickness between approximately 1.3 nm and 300 nm, where the length/thickness ratio of a majority of the nanofibers embedded in the organic matrix is greater than 10.

10. Apparatus according to one of the foregoing claims, characterized in that the length of the nanofibers, at least for a majority of the nanofibers embedded in the organic matrix, is between 1 μm – 100 μm.

11. Apparatus according to one of the foregoing claims, characterized in that the thickness of the intermediate layer (3) is between 0.01 mm and 0.5 mm.

12. Apparatus according to one of the foregoing claims, characterized in that at least part of the nanofibers are made of carbon.

13. Apparatus according to one of the foregoing claims, characterized in that at least part of the nanofibers are made of boron nitride and/or tungsten carbide.

14. Apparatus according to one of the foregoing claims, characterized in that the nanofibers (8) in the organic matrix are oriented in a random and/or tangled configuration.

15. Apparatus according to one of the foregoing claims, characterized in that the nanofibers (8) in the organic matrix at least for the most part are oriented in the same direction longitudinally, for example perpendicular or crosswise to the adjacent heat transfer surfaces (1.1, 2.1) or parallel or approximately parallel to the heat transfer surfaces (1.1, 2.1).

16. Apparatus according to claim 15, characterized by means (9) for orienting and/or maintaining the orientation of the nanofibers in the organic matrix, for example by means for creating an electric field intensity in the organic matrix.

17. Apparatus according to one of the foregoing claims, characterized in that at least part of the nanofibers embedded in the organic matrix form a two-dimensional or three-dimensional structure, in which the nanofibers are linked with each other, for example in the form of a web or web-like structure, a non-woven material structure and/or a network or screen-like structure.

18. Apparatus according to one of the foregoing claims, characterized in that the organic matrix contains further components or additives, for example in a percentage that is lower than the percentage of nanofibers.

19. Apparatus according to claim 18, characterized in that the organic matrix contains at least one thermally conductive ceramic in the form of fine particles or powder as an additive, for example Al_2O_3, AlN, BN, Si_3N_4, SiC, BeO, ZrO.

20. Apparatus according to claim 18 or 19, characterized in that the organic matrix contains as an additive at least one metal and/or metal compound and/or metal alloy in the form of fine particles or powder, for example silver, copper or gold.

21. Apparatus according to one of the claims 18 – 20, characterized in that the matrix contains as an additive, in the form of fine particles or powder, at least one material and/or material compound and/or alloy that is heat-conductive and changes to molten state at temperatures above 50°C.

22. Apparatus according to one of the foregoing claims, characterized in that at least part of the nanofibers are nanotubes, for example single-walled and/or double-walled nanotubes.

23. Apparatus according to one of the foregoing claims, characterized in that at least part of the nanofibers are coated with at least one metal.

24. Apparatus according to one of the foregoing claims, characterized in that the nanofibers made of carbon are such nanofibers that were subjected to a heat treatment or graphitization step at a temperature between 2700 – 3100°C before being embedded in the organic matrix.

25. Apparatus according to one of the foregoing claims, characterized in that the heat source (1) is formed by at least one electronic component, e.g. diode, semiconductor switch or control element (transistor, mosfet) or by an integrated component.

26. Apparatus according to one of the foregoing claims, characterized in that the heat source (1) is formed by at least one circuit or module with at least one electric or electronic component (24), which is located on a metal-ceramic substrate (22) manufactured using the DCB process or

active soldering process, wherein the intermediate layer (3) is located between one metallization (22.3) of the substrate and one heat transfer surface (2.1) adjacent to said metallization.

27. Apparatus according to one of the foregoing claims, characterized in that the heat source (1) is formed by a microprocessor.

28. Apparatus according to one of the foregoing claims, characterized in that the heat source (1) is at least one laser diode or one laser diode bar.

29. Apparatus according to one of the foregoing claims, characterized in that the heat sink (2) is formed by a passive cooler (10) with cooling fins, cooling pins or similar structures.

30. Apparatus according to one of the foregoing claims, characterized in that the heat sink (2) comprises at least one active cooler (12) through which a coolant, for example water, circulates.

31. Apparatus according to claim 30, characterized in that the at least one cooler (12) is part of a coolant circulation system.

32. Apparatus according to one of the foregoing claims, characterized in that the heat sink comprises at least one heat pipe (17, 20) and that the intermediate layer (3) is provided at least between the heat source (1) and one cooling surface formed by the heat pipe.

33. Apparatus according to claim 32, characterized in that one cooler or heat exchanger (18, 21) is provided on the heat pipe, wherein preferably at least one intermediate layer is provided between the heat pipe and this heat exchanger or cooler.

34. Apparatus according to claim 32 or 33, characterized in that the heat pipe (17) functions as a heat pump.

35. Apparatus according to one of the claims 32 – 34, characterized in that the heat pipe (20) functions as a heat spreader.

36. Thermally conductive mass, e.g. thermally conductive paste, for forming an intermediate layer (3) between a heat source (1) and a heat sink (2), characterized in that the mass consists of an organic matrix with embedded nanofibers.

37. Thermally conductive mass according to claim 36, characterized in that the organic matrix, at least at the operating temperature of the apparatus or of the heat source (1), is in a viscous or liquid state, for example a semi-liquid state.

38. Thermally conductive mass according to claim 36 or 37, characterized in that the organic matrix is already in the viscous or liquid state at room temperature, i.e. at a temperature between 10 and 30°C.

39. Thermally conductive mass according to claim 38, characterized in that the organic matrix is in the viscous or liquid state at a temperature higher than 30°C, for example at a temperature between 40 and 80°C.

40. Thermally conductive mass according to one of the foregoing claims, characterized in that the organic matrix contains at least one oil, for example a synthetic oil, such as silicone oil.

41. Thermally conductive mass according to one of the foregoing claims, characterized in that the organic matrix contains at least partially an elastomer, for example a completely or only partially cross-linked

elastomer, e.g. synthetic elastomer such as silicone rubber.

42. Thermally conductive mass according to one of the foregoing claims, characterized in that the organic matrix is at least partially a polymer, e.g. polycarbonate, polypropylene or polyethylene.

43. Thermally conductive mass according to one of the foregoing claims, characterized in that the percentage of nanofibers in the matrix is between 1 and 70 percent by weight in relation to the total mass of the intermediate layer (3), preferably between 5 and 20 percent by weight.

44. Thermally conductive mass according to one of the foregoing claims, characterized in that the nanofibers have a thickness between approximately 1.3 nm and 300 nm, where the length/thickness ratio of a majority of the nanofibers embedded in the organic matrix is greater than 10.

45. Thermally conductive mass according to one of the foregoing claims, characterized in that the length of the nanofibers, at least for a majority of the nanofibers embedded in the organic matrix, is between 1 μm – 100 μm.

46. Thermally conductive mass according to one of the foregoing claims, characterized in that the thickness of the intermediate layer (3) is between 0.01 mm and 0.5 mm.

47. Thermally conductive mass according to one of the foregoing claims, characterized in that at least part of the nanofibers are made of carbon.

48. Thermally conductive mass according to one of the foregoing claims, characterized in that at least part of the nanofibers are made of boron nitride and/or tungsten carbide.

49. Thermally conductive mass according to one of the foregoing claims, characterized in that the nanofibers (8) in the organic matrix are oriented in a random and/or tangled configuration.

50. Thermally conductive mass according to one of the foregoing claims, characterized in that the nanofibers (8) in the organic matrix at least for the most part are oriented in the same direction longitudinally, for example perpendicular or crosswise to the adjacent heat transfer surfaces (1.1, 2.1) or parallel or approximately parallel to the heat transfer surfaces (1.1, 2.1).

51. Thermally conductive mass according to one of the foregoing claims, characterized in that at least part of the nanofibers embedded in the organic matrix form a two-dimensional or three-dimensional structure, in which the nanofibers are linked with each other, for example in the form of a web or web-like structure, a non-woven material structure and/or a network or screen-like structure.

52. Thermally conductive mass according to one of the foregoing claims, characterized in that the organic matrix contains further components or additives, for example in a percentage that is lower than the percentage of nanofibers.

53. Thermally conductive mass according to claim 52, characterized in that the organic matrix contains as an additive at least one thermally conductive ceramic in the form of fine particles or powder, for example Al_2O_3, AlN, BN, Si_3N_4, SiC, BeO, ZrO.

54. Thermally conductive mass according to claim 52 or 53, characterized in that the organic matrix contains as an additive at least one metal and/or metal compound and/or metal alloy in the form of fine particles or powder, for example silver, copper or gold.

55. Thermally conductive mass according to one of the claims 52 – 54, characterized in that the matrix contains as an additive, in the form of fine particles or powder, at least one material and/or material compound and/or alloy that is heat-conductive and changes to molten state at temperatures above 50°C.

56. Thermally conductive mass according to one of the foregoing claims, characterized in that at least part of the nanofibers are nanotubes, for example single-walled and/or double-walled nanotubes.

57. Thermally conductive mass according to one of the foregoing claims, characterized in that at least part of the nanofibers are coated with at least one metal.

58. Thermally conductive mass according to one of the foregoing claims, characterized in that the nanofibers made of carbon are such nanofibers that were subjected to a heat treatment or graphitization step at a temperature between 2700 – 3100°C before being embedded in the organic matrix.